PROCESS ORIENTED QUALITY ASSURANCE

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INTRODUCTION

EC 1165-2-203 requires Major Subordinate Commands (MSC) to perform quality assurance (QA) evaluations of district engineering products. The EC states in part:

"Division QA responsibility is to evaluate and recommend changes to the district's QC process. The division QA process will assure that the QC plan for the project is appropriate. Through such QA mechanisms, the division assures that districts are able to plan, design, and deliver quality products on schedule, within budget, that are acceptable to the customer and Federal Government."

The Southwestern Division established Quality Assurance requirements through the development of a QA Plan in August 1995 essentially complying with the EC and comprising the following features.

- Approval of district Quality Management and Quality Control (QC)Plans
- Evaluation of district processes through site visits
- Interviews of district personnel of various grade levels
- Technical evaluation of the quality of selected district products
- Subjective evaluation of district product quality
- Use of indicators to define district process capabilities
- Evaluation of engineering quality during the construction process
- Evaluation of customer satisfaction related to engineering quality after beneficial occupancy.

We decided the success of our QA program required us to add value

to district products through "COACHING - ASSISTING - TEACHING" district personnel. The results achieved within Southwestern Division (CESWD) in evaluating district quality have produced some interesting insights into what is being achieved and what can be implemented to ensure continuous improvement in product quality and district processes. This paper explains the CESWD QA methods and provides recommendations to change district processes to improve the quality, timeliness, or cost of products.

QUALITY ASSURANCE PLAN AND IMPLEMENTATION

Four items are critical in the evaluation of district quality and providing improvement recommendations.

- A QA Plan that describes what is to be done
- A method to implement the QA Plan
- District support through partnering and program buy-in
- A senior level multidiscipline QA Staff

QA PLAN

CESWD developed our QA Plan from the various Task Force instructions for division and district restructuring of responsibilities. The QA Plan includes the eight essential features in EC 1165-2-203 required for an appropriate QA program. Using these features the QA Plan defines methods and anticipated results for the CESWD Quality Assurance Team in evaluating district quality and processes. Supplements and attachments to the QA Plan include: performance indicators; interview questions for site visits; and a checklist for evaluation of district Quality Management and Quality Control Plans.

QA IMPLEMENTATION AND DISTRICT BUY-IN

Implementation of our program started with furnishing each district an information package including our QA Plan, the Implementation Plan, performance indicators and other pertinent data. A request for comments on the package and announcement of a meeting for district Engineering Division Chiefs was included. The intent of the meeting was to obtain district buy-in and support for our QA program. Judging by the written district responses on our information package, we perceived a difficult task to achieve district support by the end of the meeting. Proof of the importance of coaching-assisting-teaching resulted with obtaining district buy-in and support of the QA Plan at the one-

day meeting. Scheduling initial QA Team site visits at each district achieved the initial goal of the QA Plan.

QA TEAM SITE VISITS TO DISTRICTS

The expectations of the QA Team for the district site visits were high. Numerous discussions with district counterparts resulted in agreed upon agendas and audit methods. Schedules involved site visits to the districts for two to three days, depending on district size and missions. Agendas included informal discussions concerning district processes, staffing levels/needs, organizational structure, quality control documentation, and the perceived functioning of the engineering division processes by various levels of staff.

WHAT WE FOUND OUT

Engineering design personnel usually produce quality products, on time, within budget, meeting the customer's valid requirements in spite of the engineering design processes or lack thereof! Why? Competent engineers and technicians have pride in their work and want to perform well. With that said, we found the current quality documentation maintained by the districts were not adequate to define why certain choices were made, identify possible trouble spots early in the design effort, ensure schedules and costs were properly tracked, and appropriate criteria were readily available to the designer.

SOME PROBLEMS - SOME SOLUTIONS

Achieving quality is simply accomplished by establishing facts about engineering processes defining who, what, how, and when tasks are accomplished and what is being achieved. Evaluation of these facts identifies areas for improvement. Implementation and monitoring of the change results in verification of the process improvement. Typically, this is the basis of the Shewart Cycle of Plan-Do-Check-Act (P-D-C-A). Our site visits revealed some large process related problems with simple solutions.

- Project selection for in-house design did not match in-house capabilities to project requirements. This resulted in lack of documentation (for possible process improvements) that the district had adequate technical capabilities and proper personnel to produce a quality product. Changes in district processes to match/document project requirements to district capabilities have the potential to enhance district design quality. The solution, improve the project acquisition strategy to document project technical requirements and designer/reviewer capabilities.

- Product design schedules included only the overall start date of design and the final design completion date for particular

stages. Interviewees complained the same design start and finish dates for all sections resulted in their failure to meet schedules. Enhance the scheduling process by developing overall sequential schedules for the various sections recognizing floor plans are needed prior to start of detailed mechanical and electrical design; mechanical electrical power requirements are needed prior to completion of electrical design, etc.

- Available funds and schedules were inadequate for proper Independent Technical Review (ITR). The cause appeared to be a lack of input to identify cost and schedule requirements for the review. Revise district processes to require estimated review schedules and costs to be included in the Project Management Plan (PMP) or a similar stage (for A-E work too).

- In-house designs omitted in-section checks. The cause appeared to be a lack of input to identify cost and schedule requirements for the review. Revise district processes to include schedule and cost requirements for in-section checks.

- Each designer assembles project criteria independently. Develop standard criteria packages and checklists for disciplines and specific customers. Ensure electronic media (TECHINFO and EIRS Bulletins are a good source for recent criteria changes) and hard copy criteria are readily available to the designer through the engineering division criteria system. Criteria availability is especially important to the mechanical engineer.

- Specific ITR Team members were not independent of the design. Documentation indicated Section Chiefs were performing ITR. Revise district ITR selection procedures to identify designers, in-section checkers, ITR members, and alternates in the PMP.

- Quality control documentation was incomplete. Document who, what, why, where, when, how much, and other items relating to processes and results so "what went right" and "what went wrong" in a product can form a basis for future continuous process improvement. Evaluate the "whats" after each design completion stage and develop/implement needed improvements. Use P-D-C-A.

- Lessons learned documentation was informal and inconsistent. Each district, and sometimes each section in the district, had different methods for lessons learned documentation. In some, there was no permanent documentation. Establish a formal "engineering-wide" district method for compiling lessons

learned. Electronic media may be appropriate in many cases. Assign responsibility for updating the lessons learned. CESWD is developing a standard electronic media format for district use.

- ITR Team Members did not routinely participate in engineering resolution of design deficiency type contract modifications (DDCM). Establish internal standard operating procedures to achieve participation of designer and appropriate ITR members in resolution of DDCM. Refer to CESWD-ETE-T Numbered Criteria Letter XV, 1-01, 2 April 1997. Document results in Lessons-Learned as appropriate.

- An overall schedule or work plan of current and future work within the District's Engineering Division did not exist. Software (PROMISE when available) allows the development of an overall forecast process of schedules for in-house and A-E design milestones relating to engineering work. Partnering with project management elements is recommended to develop appropriate comprehensive work plans to meet district standard operating procedures.

- Preparation of appropriate as-built drawings was a recurring problem. Engineering elements should champion the development of a team partnering effort for as-built preparation with the customer, district's construction and engineering elements, and the construction contractor. Establish detailed requirements and responsibilities for preparing as-built drawings. In the PMP address scheduling and budgeting requirements for the as-built effort.

- Downsizing and restructuring of districts had reduced some basic technical capabilities to critical levels. Mandated staffing reductions are creating a vacuum in the recruitment and development of young district designers. Restructuring to place a single type design discipline in several different sections is further compounding the problem because of on-the-job mentoring shortfalls with this type organization. Develop engineering training and recruitment plans to recognize and mitigate both short and long-term impacts of staffing reductions. Plans should address current and planned regionalization, centralization, and virtual design initiatives. These problems were especially apparent in the mechanical and electrical disciplines because of the numerous specialties.

OUTBRIEFING

The Outbriefing at each district was informal with each QA Team

member providing general observations and results of individual discipline interviews. In summary we found a quality work force of professional and dedicated employees producing quality products. However, everything was not perfect. Process problems (as noted above), staff reductions, continuous restructuring efforts, and unfunded mandates were becoming more visible roadblocks to the production of on time, within budget, quality products.

QUALITY ASSURANCE PRODUCT AUDITS

Southwestern Division QA product audits are generally accomplished after the fact. Specific product audits are a product life cycle undertaking (cradle to grave). For example in the case of an MILCON project: The project is randomly selected at 1391 startup, the district provides design data for each phase as it is developed (the QA evaluation report significantly lags the receipt of data) such as PMP/QCP, concept, annotated review comments, final design, annotated comments, RTA documents, amendments; construction aspects are monitored; and finally customer satisfaction is surveyed. Initial product audits involved one on going and one start-up project for both the MILCON and Civil Works Programs for each district. This paper addresses only the planning and engineering design phase since our product audits have not progressed into the construction or customer occupancy stages.

METHODS

The CESWD-ETE-T QA Team conducts the product audit. The team is composed of a Registered Architect, and Civil, Cost, Electrical, Environmental, Geotechnical, Hydraulic, Mechanical, and Structural Registered Professional Engineers. Team members evaluate the product information for both their discipline and compliance with overall quality considerations. No discipline area or item of quality evaluation is "off-limits" to any team member. The product audit uses three methods.

Product Technical Evaluation

This method involves a technical review to assist in determining process shortcomings and a subjective evaluation of the discipline design quality. Product evaluation occurs at each stage for design documents, comments, and comment annotations. The focus of the evaluation is on technical quality shortfalls caused by district processes involving the design, in-section checking, and ITR processes. In some instances the technical evaluation may reveal significant code/criteria violations

endangering user safety or successful achievement of customer satisfaction. In these rare instances the QA Team informally advises the district of the concerns. After the fact identification of concerns may, in some cases, impact their resolution.

Subjective Quality Evaluation

The second method of district quality evaluation is an overall and discipline specific subjective quality evaluation by each individual team member. A form similar to that for A-E evaluations (DD Form 2631) is used. Each QA Team member completes the form for the specific product stage evaluated. At project advertisement, the CESWD Engineering Division Chief assigns the product quality rating based on all the individual discipline ratings. This subjective quality rating, in combination with interpretation of technical evaluations, performance indicators, monitoring of construction and customer satisfaction interviews defines overall district quality.

Performance Indicator Measurement

This is somewhat of a bean counting exercise. Each specific discipline is involved because of the complexity of result interpretation and classification of comments into categories of technical, nontechnical, functional, and O & M. Comment count for each category is tabulated, charted, graphed, etc. and results analyzed. The resulting performance indicators are an indication of the performance capability of each district's engineering processes. As such, point by point comparison of performance measurement results between districts is relatively unreliable and best left to the CMR performance methods. The QA performance indicators for the MILCON and Civil Works design stage generally involve the following ten areas:

C Design submission schedules

C Target design costs

C Project cost

C Technical criteria

C Functional criteria

C Constructibility

C Completeness of design documents

- O & M costs
- Construction award dates
- Designer/reviewer experience

MORE PROBLEMS - MORE SOLUTIONS

Experience with the quality assurance audits of our QA program have highlighted the need for senior technical personnel to be involved in the QA effort. The technical evaluation of the district product is in reality a technical review that relates product shortcomings in facility "systems design" and criteria or regulation compliance to district engineering division processes and their implementation.

Product Technical Evaluation

This stage of district quality evaluations has revealed the majority of quality related process problems. Audits show some systemic process problems and possible solutions are:

- Processes do not assign responsibility for identifying criteria/regulation waivers to appropriate personnel. In addition personnel are not adequately familiar with all criteria to identify waiver needs. Typically in the mechanical design area changes to the CEGS highlight possible needs for waivers. District designers, and especially the ITR teams, need to become more cognizant of waiver requirements. Possible solutions include a reviewer checklist, review of "marked-up" CEGS to identify changes, and better familiarity of criteria.

- PMPs do not adequately address project acquisition strategies. PMP development receives low priority within the entire district organization. Provide explanations in the PMP to define project requirements against district capabilities. This provides an early indication of the need for any special discipline requirements such as involvement of a TCX/MCX or special consultant and the availability of appropriate designers and in-house ITR members.

- Flawed selection of "facility systems". Typically, each discipline has favorite facility systems that are repeated project after project. Revise district processes for the initial meeting of design team members to encourage outside-the-box thinking (similar to value engineering brain storming methods) to develop facility design alternatives. Ensure this process results in customer buy-in for selected facility

system solutions.

- C In-section reviewers/checkers are also members of the ITR follow on review. Revise district processes to continuously revalidate, update, and document the entire product team membership and QCP. Define various team members and alternates in the PMP.

- C Designers and checkers do not "initial" all calculations. Develop compliance methods for this item of the QCP. Designers, in section checkers and reviewers, the ITR Team Members, and Chief, Engineering Division (or similar authority) should be required to sign quality certification forms. ER 1110-345-100 contains guidance.

- C Inadequate coordination between disciplines. Regardless of criteria, checklists, designer experience, in-section checking, CADD overlays, and ITR - water piping and ductwork installed above electrical panels is a common occurrence. Since none of the above works how about a section ceremony with a "gold star" award for perfect misses (or hits) of electrical-mechanical panel interferences.

- C Routine check off of checklist items. Designer check off included inappropriate items. Require district processes to have the ITR Team spot check any checklists completed by designers and included in project documentation.

- C Comment action incorrectly annotated. Designer research and action on comments require time, so does the back-check by reviewers. Revise processes to ensure designers provide correct response action to comment annotations coordinating any deviation from the annotated response with the reviewer. Include a final in-section check to ensure the correct annotation and resultant action.

- C PMPs, where required, are poorly coordinated between project management (PM) and engineering elements. Include in engineering processes provisions for coordination with PM to ensure receipt of a copy of the original and all updates of the PMP by engineering elements. Similarly, furnish QCP revisions to PM elements.

- C The ITR provides comments using marked-up documents rather than formal comments. Revise District QCP and processes to require formal ITR comments.

- C When an A-E performs portions of an in-house design, BCO comment coordination with in-house personnel is lacking.

Additionally, evaluation of full A-E compliance with the contract scope of work may not occur. Revise district processes to route all BCO comments through the appropriate engineering elements. District processes are to define responsibilities for ensuring the A-E has met technical engineering requirements of the contract.

- QC Plans do not reflect changes in product team members. Assign responsibilities in the QCP for updates of the team member participants.

- Designers do not consult with customers concerning preferences for facility systems. Revise district processes to include provisions for soliciting input from customers for preferred building systems. Obtain waivers when customer preferences conflict with criteria.

Performance Indicator Measurements

Development of performance indicators is a long-term process requiring numerous samples to provide reliable results. Our current QA program, because of small sample sizes, has not identified capabilities of individual district processes; however, evaluation of overall results has revealed areas where significant improvements may be possible.

- ITR team members are making numerous nontechnical (such as spelling error) comments. Since misspelled words and similar errors impact the customer's perception of a quality product; the ITR members should not make this type of comment. This type of comment by the ITR also tends to indicate the design and checking of documents prior to leaving the section should be more thorough. Revise district processes to reflect appropriate procedures for ITR and in-section reviews.

- Numerous ITR team members of different disciplines accomplish detailed reviews of all portions of a design document. Instruct ITR members to perform a detailed review only for their particular discipline. Recognize the need for some minor overlap of the review effort because of multidiscipline design/review coordination.

- Experience levels selected for designers versus reviewers are inappropriate. Numerous detailed reviewer technical comments indicated a need for reversal of the designer and reviewer personnel selections. In lieu of role reversal, better mentoring by senior engineers might be used to minimize design and review costs. Revise district processes to identify, at the PMP stage, project requirements versus designer and

reviewer capabilities.

- Customers provided more technical comments than the ITR. Numerous contributing causes may exist in district processes. The customer's criteria were unknown or ITR review instructions and internal section checks were inadequate. Other factors might include insufficient review time in schedules or even insufficient review funds. Ensure district processes contain standard operating procedures for ITR, internal checks, and interface between the district design team and technical representative of customers.

- Back-check review of comments resulted in many repeat comments for those annotated concur or will comply. Include a final in-section check of comments and documents as standard district operating procedure. Any change from previously agreed comment disposition should be coordinated between the reviewer and designer.

- Technical comments indicated designers are unfamiliar with proper criteria and regulations. In some cases even the ITR members were not knowledgeable. This was a recurring item between districts and disciplines (especially for the mechanical discipline). Prolific mechanical criteria and impacting regulations do exist. A possible solution based on discussions with districts and their perceived needs is a **single document** containing cross-referenced criteria. One possible solution is HQUSACE funding of a district effort. Other alternatives include improved checklists and better criteria search procedures developed by districts, MSCs, or HQUSACE.

SUMMARY

Coaching-assisting-teaching the district about the Southwestern Division's Quality Assurance methods, procedures, and implementation has required a team partnering effort. Preliminary results indicate the independent CESWD QA evaluation can provide cost-effective improvements in district production of quality products. The recommended district process improvements highlighted in this paper demonstrate the far reaching cost effective quality improvement impacts that can be achieved by applying coaching-assisting-teaching techniques to *Process Oriented Quality Assurance*.

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